

ElectroSense

Requirements Document

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1. Introduction

1.1. Purpose

The purpose of our system is to provide a hospital mattress designed for ICU patients that incorporates sensors within. This would help healthcare workers know when something is wrong with their patient which would help make sure the ICU patients are safe and comfortable.

1.2 Scope

The main system consists of a mattress attached to various sensors connected to a central processing unit. This goes along with an IOS app to connect to the bed via Bluetooth to be able to alert nurses of rapid changes in vitals. It will also assist CNAs who are understaffed in collecting basic vitals such as heart rate and pulse oximetry as well as preventing bed sores. The system is comprised of: pressure sensors for body pressure mapping which will provide things like weight, distribution sensors for sleep analysis throughout the night, heart rate and pulse oximetry sensors to provide around the clock updates of basic vitals, bed alarm sensor to detect when the patient is rapidly moving (which could indicate convulsion activity) or when a patient on bed rest is trying to get up, temperature sensors that will be adjustable in 3 regions, it will also have circulation compression pumps combined with massager to prevent bed sores and rotate bed bound patients and heating pads meant to manipulate bed temperature.

Each of the aforementioned sensors comes with specific data gathering libraries available which will be used in order to gather acquired data in one place. We will then write collected data to a datastream connected to and sent over bluetooth, to be received, processed, and finally displayed by the phone app.

1.3 Definitions, acronyms, abbreviations:

SwiftUI: UI centered language made for app development on iOS.

XCode: Integrated development environment for Swift apps.

Arduino: A computer acting as a central processing unit.

1.4 References

1.5 Overview

This document is meant to provide a detailed description of the necessary features, design and other requirements the ElectroSense project will have to accomplish.

2. Description

2.1 Product Perspective

Many hospital employees have to face a fast paced environment in the workplace and deal with many distractions at once making their job very difficult. Therefore, many organizations around the world have begun creating patient mattresses with in-built sensors in order to lower the downtime an operator has to spend manually measuring patients. Others have created mattresses which allow for automatic bed temperature and patient positioning manipulation. However, no one has created an all encompassing system combining all these factors together.

2.2. Product functions

Pressure sensors (weight + distribution + bed alarm)

Monitor the patient's weight distribution and movements without having to get up

Heart rate sensors

Pulse O2 monitor: Transmissive pulse oximetry

Automatic ambient heater/cooling gel: Temperature sensor and adjustable temperature
Circulation (prevent blood clots): Intermittent pneumatic compression pumps
Massager/sleep quality analyzer: 3 axis accelerometer sensor

2.3 Product constraints

- Low room for error
- Hospital regulations
- Federal approval

2.5 Assumptions

- System will be used in closed environments by trained operators
- The operator will be within the range of the system's signal

3. Specific Requirements

3.1 External Interfaces

The system will have three external user interfaces: the iOS app and the patient bed. The iOS phone app will consist of a SwiftUI interface and data displays configured to showcase the data received from the bluetooth. The app is required to alert the operating technician with patient pulse oximetry, heart rate, patient movement warnings, patient temperature/heatmap. It will also be required to allow the operator to change the bed temperature and display it to the user. Everything on the app is done locally/ over a bluetooth connection so there is no need for server communication/wifi connection. In case of a system error or deviation of patient data, the app should provide a warning to the operator. The data processed by the app will need to be processed and cleaned on the client side. The app will also have to include a power off/on button alongside possible configuration settings. Due to the fact that the system is intended to be used within a fast paced environment of a hospital, the app will have to have a customer centered design with a focus on ease of use and simplicity. If ahead of schedule, an Android app will be released as well.

The bed will have to interact with its patients by reading their data. However it will also have to interact with the patients through its ability to manipulate bed temperature and physically affect the patient with the circulation pumps. This interface that interacts with the patient through the bed cannot have any room for errors, and will have to be able to process emergency shutdown signals both from the patient and nurse, due to preventing any chance of harm to the patient in case of major malfunction. Rigorous safety testing will need to be performed and limitations imposed on the range of manipulation and force of the instruments used to interact with the patient. For example, there has to be an imposed limit on the possible temperature a bed can be set to, so that no one can set the temperature too high and harm the patient.

The sensors will have to be positioned in a plethora of places along the bed and there will have to be a plentitude of sensors per each category. All of the sensors can have a separate refresh rate because their data displays on separate screens. The sensors will send a constant stream of data to the connected iOS device which will process it as it receives the data. Each of the related displays will have a consistent "real-time" refresh rate and "real-time" deviation detection with warnings sent to the operator on a per case basis.

3.2 Functional requirements

The benefits of using a bluetooth device to transmit data rather than a server is that anyone will be able to connect to the data stream transmitted by the bed with relative ease as long as they have a phone. The main constraint is that there will be an imposed range of connection based on the specifics of the bluetooth device involved. The presumption is that a connection will have to be established within an area approximately equivalent to the area of a hospital ward.

Due to the modularity of the system, software maintenance has to be a relatively straightforward process with no potential of error propagation from one part of the system to the others.

As the system is founded on bluetooth communication which will be the only way to access it, the security of the system is dependent on the inbuilt security within Bluetooth. Since the device will only be accessible from a secure small environment, the amount of potential malicious attacks on the system is heavily mitigated. Furthermore, the inbuilt constraints on the system will make it impossible for a highly harmful attack to happen to a patient by a malicious agent. Any form of operator restriction will not be within the scope of our project.

It should also be easy for different users to access a single bluetooth device interchangeably so that multiple workers can switch in between monitoring patients as easily as possible. This is the main benefit of using a bluetooth connection.

3.3 Performance requirements

Data coming in from the bluetooth signal will have to be processed and cleaned on the client side due to the restriction of processing power within the Arduino used to send data, this might result in delays between the data collected by the sensors and data shown to the operator by the app. This delay will have to be less than a second as it is imperative the operator is alerted as soon as possible of any discrepancies in patient status.

3.4 Non functional requirements

The fact that our target customer is a medical professional, a strong degree of detail in patient data will need to be displayed to the operator in a small space subject to changes in its dimensions on a per phone basis which we will need to take into account. The app will require responsive design.